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21NOV02 E765345-1 D02776
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1.	Your reference	QIP/P3335
2.	Patent application number *(The Patent Office will fill in this part)*	0227206.0
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	QINETIQ LIMITED Registered Office 85 Buckingham Gate London SW1E 6PD United Kingdom
	Patents ADP number *(if you know it)*	818385 7001
	If the applicant is a corporate body, give the country/state of its incorporation	GB
4.	Title of the invention	Electrical Transmission System
5.	Name of your agent *(if you have one)*	Robert William Obee
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	QINETIQ LIMITED IP Formalities A4 Bldg Cody Technology Park Ively Road Farnborough Hants GU14 0LX United Kingdom
	Patents ADP number *(if you know it)*	8504581001
6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country / Piority application number *(if you know it)* / Date of filing *(day / month / year)*
7.	If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number or earlier application / Date of filing *(day / month / year)*
8.	Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	YES

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Continuation sheets of this form

Description 4

Claim(s) 2

Abstract 1

Drawing(s) 2 only 8

10. If you are also filing any of the following, state how many against each item.

Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*

Request for preliminary examination and search *(Patents Form 9/77)* 1

Request for substantive examination *(Patents Form 10/77)*

Any other documents *(please specify)*

11. I / We request the grant of a patent on the basis of this application.

Signature R W Obee, Agent for the Applicant Date 21/11/2002

12. Name and daytime telephone number of person to contact in the United Kingdom Mrs Linda Bruckshaw 01252 392722

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DUPLICATE

ELECTRICAL TRANSMISSION SYSTEM

The present invention relates to the transmission of electrical energy between different parts of a structure - especially underground, sub-sea or sub-seabed structures. The invention is more particularly, though not exclusively, concerned with transmission along oil and gas pipelines, and especially in wells.

Oil and gas wells conventionally utilise substantial lengths of steel pipework during drilling/perforating operations and, during production, for conveyance of the oil or gas to the surface. They are also typically equipped with perforators, pumps, valves, actuators, flowmeters, strain gauges, temperature and pressure monitors and/or other downhole instrumentation at the base of the well, and optionally at other selected positions along the pipework, requiring the transmission of electrical power and/or data signals from/to the surface. The use of conventional discrete electrical cabling for this purpose is problematical, however. It has to be attached to the well pipework at a large number of separate, carefully chosen locations in an effort to minimise the likelihood of breakage or damage to the conductors or their insulation. Placement and protection of discrete cabling is time consuming and does not always avoid the problems of breakage or damage.

The present invention seeks to avoid these drawbacks and in one aspect resides in a structure of electrically conductive material provided with means for the transmission of electrical energy between spaced locations along the structure, comprising a first layer of electrically insulative material deposited on the structure, one or more electrically conductive tracks deposited on said first layer, and a second layer of electrically insulative material deposited over said electrically conductive track(s).

The invention also resides in a method of providing a structure of electrically conductive material with means for the transmission of electrical energy between spaced locations along the structure which comprises the steps of: depositing a first layer of electrically insulative material on the structure; depositing one or more electrically conductive tracks on said first layer; and depositing a second layer of electrically insulative material over said electrically conductive track(s).

By thus providing insulated conductors integral with the structure the use of separate cabling for the transmission of power or data signals between different locations on the structure may be avoided.

These and other features of the invention will now be more particularly described, by way of example only, with reference to the accompanying schematic drawings in which:-

Figure 1 is a cross section through part of a structure to which the invention may be applied, namely an oil well installation;

Figure 2 is transverse cross section through part of the pipe string illustrated in Figure 1; and

Figure 3 is an end/side view of part of the pipe string illustrated in Figure 1.

Figure 1 is a simplified cross section through part of a production oil well installation to which the invention may be applied. It comprises a borehole through earth formation 1 lined with a steel casing 2. Running down through the casing 2 from the surface to the oil reservoir below is a steel pipe string 3 assembled from successive sections 3A joined end to end, and through which oil is conveyed to the surface. Depending on the construction and location of the installation the annulus 4 between the pipe string 3 and casing 2 may contain, at different depths, earth, oil or water, or cement or other packers to prevent displacement of the pipe string in the borehole.. Although not shown in the Figure, various equipment and instrumentation associated with the operation of the well will be located at its base, and other instrumentation for monitoring the condition of the pipe string 3 may be located at various positions along its length, to which electrical power must be transmitted from the surface and/or from which electrical data signals must be transmitted to the surface. For this purpose each length of pipe 3A is provided with a multilayer coating as will now be described with reference to Figures 2 and 3.

Figure 2 is a transverse cross section through a length of pipe 3A and its applied coating, not to scale, and Figure 3 is an end/side view of the structure of Figure 2, again not to scale, and with the outer coating layer partially omitted for ease of illustration.

A first layer 5 of electrically insulative material is deposited along the length of the outer surface of the pipe 3A over part (as shown), or possibly all, of its circumference. A series of parallel tracks 6 of electrically conductive material are then deposited on the insulative layer 5. Finally, a second layer 7 of electrically insulative material is deposited over the tracks 6 and on to the layer 5 between and around the tracks. In use the tracks 6 serve for the transmission of electrical energy along the length of the pipe to/from the

various downhole equipment and/or instrumentation. The pipe 3A may itself serve as an additional transmission path. The provision of multiple tracks 6 enables a plurality of separate channels to be defined to a range of different equipment and/or instrumentation types, and useful redundancy in the event that individual tracks become damaged.

Layer 5 serves to electrically insulate the tracks 6 from the pipe 3A and is preferably composed of a ceramic material, typically 0.1 to 0.3mm thick. Layer 7 serves to electrically insulate the tracks 6 from the environment or structure external to the pipe and to provide physical protection for the conductive tracks during handling, installation and use. It is also preferably composed of a ceramic material, with a thickness of typically 0.1 to 0.3mm above the tracks 6. The compositions of the layers 5 and 7 may be the same or different, as layer 5 will be selected primarily for its electrical resistivity while layer 7 is selected also for mechanical and chemical durability under the conditions likely to prevail in the intended service of the pipe. In one example which has been found to combine good electrical isolation with mechanical robustness and resistance to oil and seawater the ceramic composition is predominantly alumina (Al_2O_3) blended with a minor proportion of titania (TiO_2). The conductors 6 are preferably of copper, typically 0.25mm thick.

The materials 5, 6 and 7 are each preferably applied by a thermal spray process, either plasma spraying or high velocity oxy fuel (HVOF) spraying, with the use of suitable masks to define the bounds of the conductive tracks. Plasma spraying is a known process involving the use of a high temperature plasma flame into which powder is injected, where it is rapidly heated and accelerated to a high velocity. The resultant stream of molten particles is directed against the substrate surface, where the particles coalesce and cool to form a coating. HVOF spraying is another known process where fuel (e.g. kerosene) and oxygen are fed to a combustion chamber where the fuel is burnt to produce a hot high pressure flame which is accelerated through an associated nozzle. Powder is injected into the combustion chamber or nozzle and once again the resultant stream of molten particles is directed against the substrate surface, where the particles coalesce and cool to form a coating.

Although not shown, the tracks 6 will be provided with terminations at each end of the pope 3A through which they can be electrically connected to the corresponding tracks on the next pipe length, and terminals will also be provided where required for connection to

the respective downhole equipment/instrumentation. This may be accomplished through selective masking of the tracks during application of the layer 7.

CLAIMS

1. A structure of electrically conductive material provided with means for the transmission of electrical energy between spaced locations along the structure, comprising a first layer of electrically insulative material deposited on the structure, one or more electrically conductive tracks deposited on said first layer, and a second layer of electrically insulative material deposited over said electrically conductive track(s).

2. A structure according to claim 1 wherein the electrically insulative material in said first and/or second said layer is a ceramic.

3. A structure according to claim 2 wherein the electrically insulative material in said first and/or second said layer is composed predominantly of alumina.

4. A structure according to claim 3 wherein the electrically insulative material in said first and/or second said layer includes a proportion of titania.

5. A structure according to any preceding claim wherein one or more of said first and second layers of electrically insulative material and said electrically conductive track(s) were deposited by a thermal spray process.

6. A structure according to claim 5 wherein one or more of said first and second layers of electrically insulative material and said electrically conductive track(s) were deposited by plasma spraying or high velocity oxy fuel spraying.

7. A structure according to any preceding claim being a length of pipe.

8. A structure according to any one of claims 1 to 6 being a pipeline for the conveyance of oil or gas.

9. A structure according to claim 8 being a pipeline in a well.

10. A structure of electrically conductive material provided with means for the transmission of electrical energy between spaced locations along the structure, substantially as hereinbefore described with reference to the accompanying drawings.

11. A method of providing a structure of electrically conductive material with means for the transmission of electrical energy between spaced locations along the structure which comprises the steps of: (1) depositing a first layer of electrically insulative material on the structure; (2) depositing one or more electrically conductive tracks on said first layer; and (3) depositing a second layer of electrically insulative material over said electrically conductive track(s).

12. A method according to claim 11 wherein the electrically insulative material deposited in step (1) and/or (3) is a ceramic.

13. A method according to claim 12 wherein the electrically insulative material deposited in step (1) and/or (3) is composed predominantly of alumina.

14. A method according to claim 13 wherein the electrically insulative material deposited in step (1) and/or (3) includes a proportion of titania.

15. A method according to any one of claims 11 to 14 wherein one or more steps (1), (2) and (3) comprises a thermal spray process.

16. A method according to claim 15 wherein one or more of steps (1), (2) and (3) comprises plasma spraying or high velocity oxy fuel spraying.

17. A method according to claim 11 substantially as hereinbefore described with reference to the accompanying drawings.

ABSTRACT

Electrical Transmission System

A system for the transmission of electrical energy between different parts of an electrically conductive structure, and in particular for transmission of power and/or data signals to/from downhole equipment or instrumentation in oil and gas wells. A first layer of electrically insulative material 5 is deposited on the structure (e.g. oil pipe string 3A), followed by a series of electrically conductive tracks 6 and a second layer of electrically insulative material 7. The tracks 6 which serve for the transmission of power and/or data signals are thus sandwiched between the layers 5 and 7, insulated from the structure 3A and the external environment and protected from damage. Each layer 5,6 and 7 is preferably deposited by a thermal spray process such as plasma spraying or high velocity oxy fuel spraying.

Figure 2 refers.

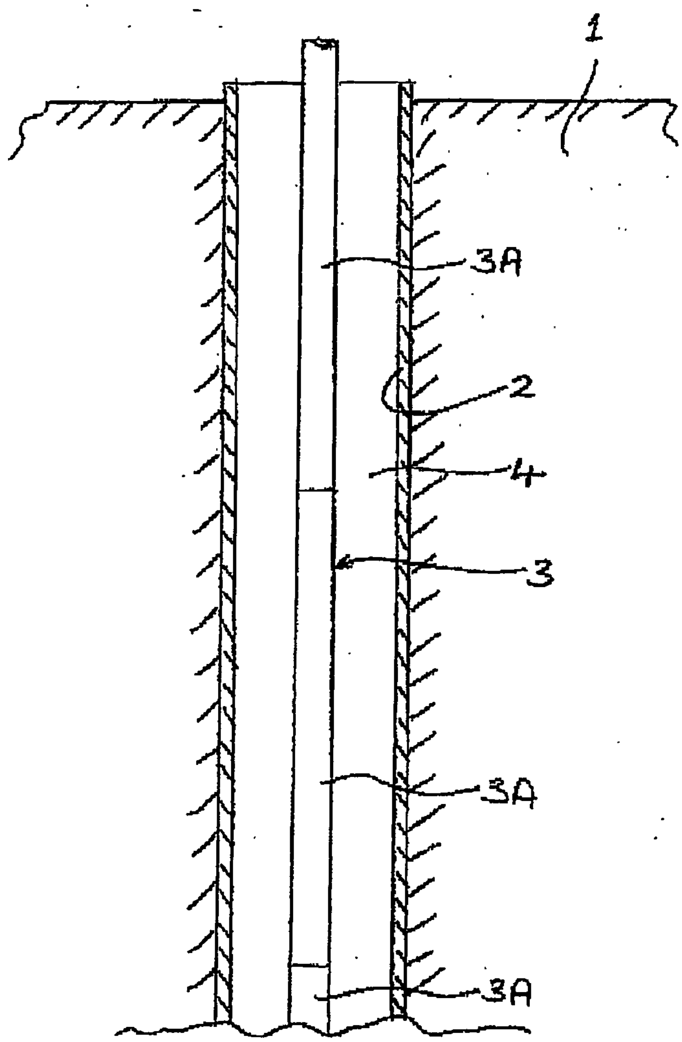

Fig. 1

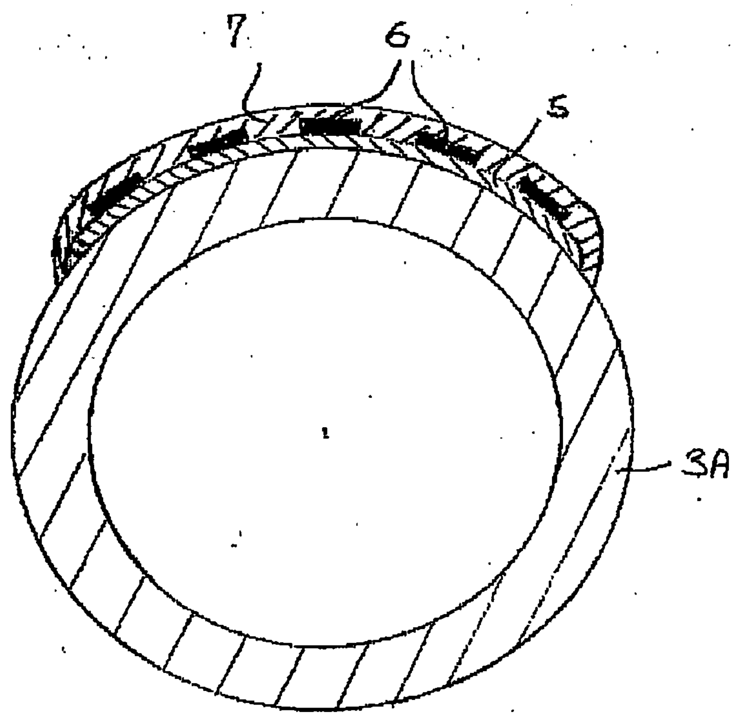

Fig. 2

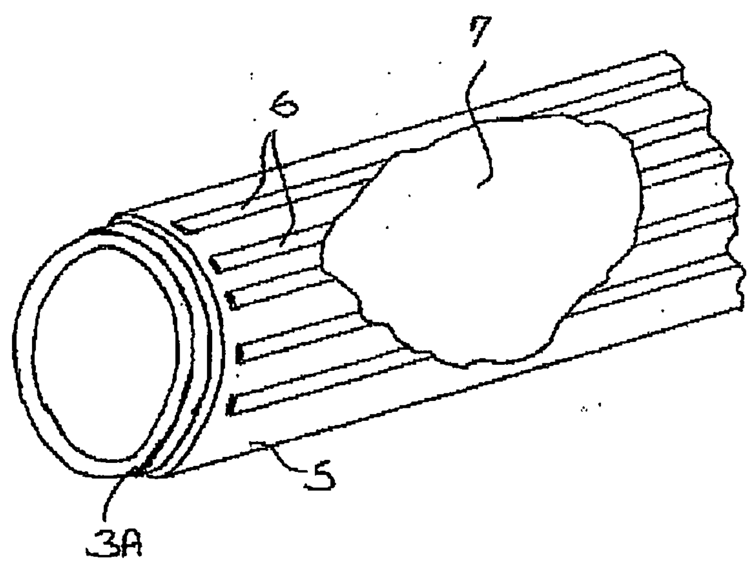

Fig. 3